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DEVICE FOR TRANSVERSE IMMOBILIZATION OF NUCLEAR FUEL ASSEMBLIES INSIDE TRANSPORT CONTAINERS

Background of the Invention

~~Technical field~~ Field of the Invention

The invention relates to a device for transversely immobilizing nuclear fuel assemblies in their transport container.

Discussion of the Background ~~State of prior art and problem caused~~

New, long uranium oxide based fuel assemblies with a prismatic shape intended for use in nuclear power stations, for example of the PWR or BRW type, are normally transported in relatively light containers or canisters (total laden weight not exceeding 5 t).

The container usually contains two to four assemblies placed in housings or cradles, by means of individually adjustable devices so that the said assemblies can be accessed directly over their entire length.

Due to this direct access, the assemblies can be immobilized transversely in their cradle, usually located at spacing grids. In particular, this immobilization guarantees the integrity of the assemblies that must not be subjected to forces exceeding the allowable limits imposed by the designer of the assembly model, during transport or handling. Furthermore due to this direct access, the various technical problems caused by safety in these transport systems (criticality, shielding, temperature, mechanical) are solved simply.

However, the recent use of mixed fuels, in other words containing a mixture of uranium and plutonium oxide, which is to become generalized, requires

enhanced safety measures during transport, particularly for sea transport to other countries.

Thus, this transport must now be done in heavy containers with thick walls of the 100 t class, of the type used for the transport of irradiated assemblies.

These heavy containers comprise a long, thick cylindrical wall (usually about 20 to 40 cm thick) made of steel or cast iron, with a thick permanently fixed bottom at one of its ends, and closable at the other end by one or several thick removable covers. They are loaded through the end that can be closed.

The container cavity usually comprises a storage compartment comprising long compartments parallel to the center line of the container, the shape of each compartment being designed to match the type of fuel assembly to be housed in it.

Due to the fact that loading takes place through one end of the container, it is impossible to have direct access to the entire length of the assembly and to immobilize fuel assemblies in their compartments transversely in the same way as was done before.

Summary of the Invention

Thus the applicant searched for a device that could immobilize the fuel assemblies transversely working from the open end of the container, after the assemblies had been put into their compartments.

~~Description of the invention~~

The invention is a device for transverse immobilization of long nuclear fuel assemblies housed in compartments of the same length, delimited by walls, characterized in that it comprises:

- a fixed structure rigidly attached to the compartment, located on one of its surfaces and

comprising at least one guide element transverse to the length of the assembly,

- a structure that can be moved in the transverse direction, capable of applying pressure on the fuel assembly and comprising at least one transverse guide element working in cooperation with the fixed structure element,
- an adjustable clamping means comprising at least one adjustable clamping element capable of clamping or unclamping the mobile structure on the fuel assembly using an adjustment device, and a control device that can be manipulated from the accessible end of the fuel assembly, the said control device acting on the clamping element or its adjustment device to clamp the assembly in position by reaction on the fixed structure, or to release it.

The fixed structure may be a section or segments of rigidly fixed sections along the length of the compartment. It may also form an integral part of the compartment.

The mobile structure usually includes a plane plate parallel to a surface of the compartment; it is usually a portion cut out of the compartment wall. In order to immobilize the fuel element, it usually bears on the fixed structure and applies pressure on the spacing grids of the said fuel assemblies, so that the clamping force can be distributed over the entire length of the said assembly.

The clamping means usually comprises several identical clamping elements each with its own adjustment device.

Clamping elements may be rigid, or preferably elastic (spring leaf). They may be fixed to the fixed or mobile structure or the control device. The same is true for the adjustment devices with which they work in cooperation. The clamping force can be adjusted or released, depending on the relative position of the clamping elements and their adjustment devices.

The control device may act simultaneously on all clamping elements or adjustment devices. It can be operated from outside the compartment containing the fuel assembly; it is typically open at one of its ends, namely the end at which the container containing the compartments can be closed. Thus, there is no need for access to the entire length of assemblies installed in their compartments in order to immobilize them.

The control device may be operated mechanically, hydraulically or electrically. Control devices for several compartments may be grouped together.

Fixed and mobile structures may beneficially be connected to each other by return springs that facilitate the clamp release operation necessary to extract the assembly from its compartment.

In general, fixed and mobile structures are located on the same compartment wall.

Transverse guide elements are usually cylindrical and slide into each other; they comprise a male part and a female part, one being on the fixed structure and the other on the mobile structure; they may also be slides or slide elements distributed along the fixed and mobile structures, or any other equivalent system.

A compartment may comprise one or several immobilization devices located on one or several of its surfaces, in order to provide transverse immobilization

of the assembly in all directions. Thus, when the cross section of the compartment is square, it is useful to place an immobilization device on two adjacent surfaces.

In a heavy container of the type described above, there are usually a plurality of compartments with their immobilization devices that can be manipulated and adjusted from the open end of the said container. The compartments may be made fixed to each other to form a long compartment with a compartmentalized structure, each compartment comprising at least one immobilization device. Compartments have a prismatic cross-section corresponding to the cross-section of the assembly that will fit into them.

Brief Description of the Drawing

Figures 1 to 4 illustrate the invention and provide a better understanding of it.

- figures 1a and 1b show a cross-section and longitudinal section respectively through a compartment in which a single assembly of guide elements and clamping means according to the invention have been shown, although usually several of these devices are installed along the compartment.
- figures 2, 3 and 4 represent three practical alternative embodiments of clamping means that are controlled from the end of the assembly, according to the invention.

Description of the Preferred Embodiments

Figure 1 shows a compartment 1 and a housing 2 in which a fuel assembly (not shown) with a square cross-section will be positioned.

The fixed structure 3 is rigidly fixed to a wall 4 of the compartment. A female transverse guide element 5 is attached to it.

The structure 6 free to move transversely is a plane plate parallel to the assembly, and preferably partly or sometimes completely replaces the wall of the compartment. A male transverse guide element 7 is fixed to it and works in cooperation with the female guide element 5 on the fixed structure 3. Usually, this mobile structure immobilizes the fuel assembly by applying pressure to its spacing grids.

The adjustable clamping means with its remote control device is shown diagrammatically 8, and is located between the fixed and mobile structures.

Figure 2a (longitudinal section) and figure 2b (cross-section) show a first alternative embodiment of the adjustable clamping means with its remote control device.

A clamping element can be seen in the form of one or several spring leaves 10 separated from each other, in which one free end bears on a plate 11 rigidly fixed to the structure which is free to move in the transverse direction 6, and the other end is fixed to the fixed structure 3 through a hinge 12 and its support 13. The adjustable clamping force is applied by pressing on each of the spring leaves 10 using an adjustment device comprising the same number of bars 14 fixed rigidly at one or both ends to an upright 15 parallel to the major axis of the assemblies, moveable in this "longitudinal" direction used as a control device. The end of the upright 15 is located at the free end of the compartment located on the opening end of the container.

Thus, it can be seen that by manipulating the rigid control device 14, 15 longitudinally, the clamping of the fuel assembly can be adjusted starting from the

open end of the container, by pressing more or less on the leaves 10.

The upright 15 can be moved longitudinally by sliding it in a section 16 with an appropriate shape, rigidly attached to the fixed structure 3.

Several clamping assemblies comprising leaves 10, their articulated attachment 12, 13 and the thrust plate 11 are usually set out along the compartment, the control device then comprising the same number of sets of bars 14. Similarly, it is usually, and in general, advantageous to place two control devices with their elements and the associated clamping devices, in parallel on the same side of the compartment.

Figure 2a also shows a transverse guide device comprising a male guide element 7 fixed on the mobile structure 6. The corresponding female guide element 5 is attached to the fixed structure 3; a return spring device is shown in 17.

Figures 3a (longitudinal section) and 3b (cross-section) show a second alternative embodiment of the adjustable clamping means with its remote control device.

The clamping means comprises at least one clamping element comprising an elongated curved spring leaf 20, placed longitudinally; its convex surface is located facing the structure 6 free to move transversely (usually composed of the wall, or parts of the wall, of the compartment, as already mentioned); it is fixed on a support 21 at one of its ends, the support sliding longitudinally, projecting from the accessible end of the compartment containing the fuel assembly and which can be manipulated from the open end of the container. This support 21 bears on the fixed structure 3 attached

to the compartment 4. The other end of the leaf spring 20 remains free, and is supported on the said fixed structure preferably through the support 21.

The adjustment device contributing to immobilizing the assembly in the compartment comprises essentially a roll 22 and its support 23 rigidly fixed to the mobile structure 6 the roll being laid out such that it is supported on, and cooperates with, the convex surface of the leaf spring 20 to control the transverse displacement of the mobile structure 6 and the adjustable clamping of the fuel assembly.

This illustrates how the clamping can be adjusted from the outside of the container by more or less sliding the support 21 to provide a variable pressure on the roll 22 and therefore on the mobile structure 6.

As before, several clamping assemblies of this type may be distributed along the compartment. The transverse guide means that may be similar to those in figure 2a, are not shown.

Figure 4 (longitudinal section) represents a third alternative embodiment of the adjustable clamping means with its remote control device.

This clamping means comprises essentially at least one pair of connecting rods 31, 32 (in this case two pairs are shown), one of the ends being fixed using a hinge to a sleeve 33 free to move longitudinally and acting as the adjustment device. The other end of the "fixed" connecting rod 31 is rigidly attached to the fixed structure 3 through another hinge, whereas the other end of the "mobile" connecting rod 32 is rigidly attached to the mobile structure 6 once again through a hinge. Connecting rods 31, 32 are positioned so that they form a V and may advantageously be spring leaves.

Sleeve 33 is moved longitudinally by any means projecting from the accessible end of the compartment, advantageously using a worm screw 34 that does not move longitudinally, for example rigidly attached to the fixed structure 3; the said worm screw 34 then cooperates with a screw thread formed in the sleeve 33. The worm screw 34 may be fixed longitudinally by means of at least one support arm 35 fitted with an oblong bore enabling the worm screw 34 passing through it to move transversely in a direction perpendicular to the fixed structure 3 and the mobile structure 6. The support arm 35 with its oblong bore cooperates with a bearing located on the said screw 34 between two stops preventing it from moving in the longitudinal direction.

It can be seen that rotation without longitudinal displacement of the screw 34 controlled from outside the container causes a variable opening in the V formed by the connecting rods 31, 32, such that the fuel assembly clamping force can be adjusted.

As before, several devices comprising sleeves 33 with their connecting rods 31, 32, may be placed along the length of the compartment and the transverse guide means, which may be similar to those in figure 2a, are not shown.

However, these guide means may advantageously be replaced by connecting rods 31, 32, usually at their hinged end on the sleeve 33, with a device working in cooperation with the worm screw 34 (for example a sector of toothed wheel) in order to impose a variable angle on the V formed by the connecting rods 31, 32, depending on the position of the sleeve 33 and in order

to provide the transverse guide and clamping for the mobile structure 6.

Figure 5 (longitudinal section) represents a fourth alternative embodiment of the adjustable clamping means with its remote control device.

This means with pneumatic control comprises essentially a cylindrical jack body 41 with its axis in the transverse direction, rigidly attached to the fixed structure 3 and comprising a guide rod 42 along its axis, with an inlet duct 43 drilled along its axis to carry a compressed gas opening out at its end.

A fixed piston 44 is rigidly attached to the said end of the guide rod 42; it comprises seals 45 at its periphery.

The periphery of jack body 41 comprises a plurality of cylindrical chambers 46 with their axis parallel to the axis of the piston; there is a compression spring 47 in each of the chambers.

A mobile collar 48 inside the jack body 41 is adjusted to the shape of the said jack body; this collar is inserted between the fixed piston 44 and the jack body 41 and slides along the guide rod 42 by means of a corresponding bore formed in the said collar 48.

The collar 48 also comprises a plurality of housings 49 around its periphery that nest onto each of the chambers 46 in an adjustable manner.

The collar that is moved transversely to the longitudinal direction of the fuel assembly is rigidly attached to the mobile structure 6.

A compressed gas, typically air, may be added into the space located between the fixed piston 44 and the mobile collar 48 through duct 43.

The seal is formed by seals 45 located around the periphery of the fixed piston 44 and by a seal 49 located in the bore of the collar 48 and bearing on the guide rod 42.

It can be seen the mobile structure 6 is clamped onto the fuel assembly by the springs 47, and that the compressed gas is used to release and/or adjust the clamping force by counterbalancing the force applied by the springs 47. It can also be seen that the compressed gas may easily be supplied and adjusted starting from the open end of the container.

One particular advantage of this device is that it provides both transverse guide means for the mobile structure 6 and clamping means.

As before, several devices of this type are usually distributed along the compartment.

One alternative of this device consists of adapting it such that the compressed gas, for example added between the mobile collar and the jack body, controls clamping of the said mobile collar which is then modified such that the said space is gastight and the return springs release the clamping forces.

Other alternatives of the adjustable clamping means according to the invention could be made. For example, it would be possible to use a control device comprising a rod or a worm screw projecting from the free end of the compartment, as in the third alternative above, which controls the movements of clamping cams which bear on the mobile structure when the said rod or screw is manipulated.